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Substitution effect of Noug seed cake (*Guizotia abyssinica*) with Korch /Eritrnia buruci/ leaf meal on growing Doyogena lambs fed on desho (*Pennisetum glaucifolium*) grass hay as basal diet

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ABSTRACT

Background: *In central Ethiopia, livestock production is constrained by limitation in the quality and quantity of feed. This study investigated the potential of Erythrina brucei leaf meal as an alternative protein source to noug seed cake in the diets of growing lambs*

Objective: *This study investigated the impact of the substitution on animals' feed consumption, digestibility performance, growth rate, and carcass outcomes.*

Methodology: *Twenty Doyogena lambs (21.80± 0.02 kg initial weight) were used in randomized complete block design. Over a three-month period, lambs were fed a basal diet of desho grass hay and one of four concentrate mixture: T1 (157 g noug seed cake, control), T2 (92 g noug + 95 g of E. burucci), T3 (50 g noug + 155 g E. burucci), and T4 (223 g E. burucci.*

Results and Discussion: *No significant difference were observed among treatmentsfor the feed intake, nutrient digestibility, body weight gain (overall mean 53.2g/head/day), or carcass characteristics. The complete substitution with E. burcei leaf meal (T4) was found to be economically feasible.*

Conclusion: *Erythrina burucci leaf meal can effectively replace noug seed cake as a protein supplement in the diets of growing Doyogena lambs with adverse effect on performance, offering a viable and cost-effective alternative for farmers and feed processors in central Ethiopia.*

Keywords: *Helicorvepa armigera, Bemisia tabaci, Vigna unguiculata, Gossypium hirsutum, Cotton-cowpea intercrop.*

Introduction

Despite possessing one of the large livestock populations in Africa- including 66.261 million cattle, 38.013 million sheep, 45.716 million goats and millions of other animals [1]-Ethiopia faces chronically low livestock productivity. The primary constraint is a critical shortage in the quantity and quality of feed resources [2], [3]. This is exemplified by the heavy reliance on natural grazing (57.8%) and low quality crop residue (29.8%), with only minimal use of improved feeds (0.38%) [1]. The scarcity of forage during dry season and the low energy density of available are major factors limiting animal performance [4]

Sheep production, a cornerstone of Ethiopian's mixed farming systems, is under pressure from population growth, urbanization, and climate change.

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The productivity of indigenous breed like Menz, Arsi-Bale, and Blackhead Somali) is often low in terms of weight gain and carcass yield [5].While import of exotic breeds with high dressing percentages to improve meat yield and quality. However, exotic breeds like Awassi and Corriedale were attempted to improve meat yield, these breeds have struggled to adapt to local management and climate [6]. Consequently, the rising demand and price for mutton over the past decade necessitate alternative strategies to enhance productivity. A promising approach is to improve the plane of nutrition for adapted indigenous breed through supplementation. Indigenous sheep are valued for their resilience to poor nutrition and disease, and community based breed selection programs are advocating for their genetic improvement as a solution [6]. The Doyogena sheep in particular, is recognized for its good fattening potential and growth capacity in the central Ethiopia region [9] [10]. Unselected male sheep from such programs need to be castrated and finished, but appropriate and cost-efficient feed formulation for this purpose are understood. Developing feeding system that better utilize locally available resource is crucial for addressing the challenges of global warming and resource depletion [11] [12]. The multipurpose tree legume *Erythrina brucei* is one such potential nutrient source. Preliminary research has identified several E'. brucei provenances as a high-quality forage due to high dry matter and nitrogen degradation rates but its effect on animal performance requires investigation [13]. Therefore, this study aimed to determine the effect of supplementing Doyogena lambs with *Erythirnia brucei* leaf meal as a protein source. The specific objectives were to evaluate its impact on feed intake, weight gain, carcass traits and feed and economic efficiencies, thereby providing critical information for smallholder farmers facing widespread protein and calorie malnutrition.

Material and Methods

Description of the study area

The study was carried out at the Mante Dubo Research Station, which operates as a sub-site of the Areka Agricultural Research Center. The station is located about 7 km northwest of the main center and roughly 306 km from Addis Ababa. It lies at 7°20' N and 37°50' E, with an altitude ranging between 1,900 and 2,800 meters above sea level. The area receives an average annual rainfall of 2,121 mm and supports a mixed crop–livestock farming system. These diverse agroecological conditions make the site suitable for testing agricultural technologies under variable field environments.

Preparation of Experimental Feeds and Feeding Procedures

The experimental feeds were desho grass (*Pennisetum Pedicelatum*) hay, Doug seed cake meal, and dried E. brucie leaf meal. Desho grass hay was prepared at the Mante Dubo sub-station. It was harvested at an early stage (2 months of age), wilted, dried in the shade, and stored as hay at a moisture content of 10-15%. The hay was chopped into smaller pieces manually to facilitate the intake and palatability, and_reduce selective feeding by the sheep.

Purposefully, young kroch leaf was harvested from 2-4 years old trees from nearby farmers' land, which was already planted for the purpose of a living fence. The leaf was harvested manually during the rainy season (June- August) by hand-picking. The leaves were subjected to air drying under the shade on a plastic sheet to keep the nutrient quality from deteriorating. The dried *Erythrina brucei* leaves were easily crushed by hand when pressed and packed in the sack, then stored in a dry place until the feeding trials were started.

Noug seed cake meal and wheat bran were bought from Hossana city of Jon farm oil and feed processing industry.

The noug seed cake meal and *Erythrina brucei* leaves meal were mixed until the CP content became similar in each treatment. The formulated feeds were offered daily at 8:00 am and 4:00 pm, and water and mineral salt licks were accessed freely to all lambs. Common for all treatments, 200 g of wheat bran was given in equal amounts for all lambs /day once to satisfy the daily energy requirements of lambs [14].

Animals, Housing and Management

Twenty intact male Doyogena lambs (aged 6-9 months) were procured from a local market and transported to Areka Agricultural Research Center, Mante Dubo sub-station. The age was estimated by dentition, owner information, and overall appearance. Upon arrival, lambs were ear-tagged and quarantined for 15 Days, during which they were treated with albendazole and for parasite control. Following quarantine, the lambs were housed in individual pens, each equipped with a hay trough, and separate buckets for supplement and water, and subjected to a 15-day acclimatization period. The 90-day experimental feeding trial was conducted thereafter, with pens and troughs cleaned daily before feeding.

Experimental Design and Treatment Arrangement

The study employed a randomized complete block design (RCBD) consisting of four dietary treatments. Lambs were initially stratified into five blocks based on their starting body weight, and animals with similar weights within each block were randomly assigned to one of the four treatments. This approach helped minimize variability and ensure balanced representation across treatments.

$T_{1=}$Desho hay adlibtum + 157 g noug seed cake (control)

T_2=Desho hay adlibtum + 92 g noug seed cake + 95 g dried *Erythrina brucei* leaf meal

T_3=Desho hay adlibtum + 50 g noug seed cake + 155 g dried *Erythrina brucei* leaf meal

T_4=Desho hay adlibtum + 223 g dried *Erythrina brucei* leaf meal

Table 1. Arrangements of the experimental feeds and its CP content in g/kgDM

Treatment	animal	Basal dietDesho Hay (DH)	Wheat bran, g/ head /day	Amount of substitution level in g / head / day		CP g/kgDM	Amount of daily supplement in g DM /day/head
				Noug Seed cake meal	Dried E. brucei leave meal		
T1	5	DH	200	157	0	45.43	357
T2	5	DH	200	92	95	45.92	387
T3	5	DH	200	50	155	45.63	405
T4	5	DH	200	0	223	45.31	423

Data collection

Data collection focused on feed intake, body weight gain, digestibility, and carcass traits for all experimental lambs throughout the study period.

Feed and nutrient intake

The daily amounts of feed offered and refused were weighed for each lamb using a sensitive balance. A representative sub-sample (20% of the refusals) was collected daily for chemical analysis. Average daily feed intake (ADFI) was determined on a dry matter (DM) basis as the difference between the feed offered and the feed refused.

Body weight gain and feed conversion efficiency of the lambs

The live body weight of each lamb was measured every seven days after an overnight fast, and for analysis these values were converted to fifteen-day intervals.

Initial and final body weights obtained over the 90-day feeding period were used to determine total weight gain.

Average daily gain (ADG) was calculated by subtracting the initial weight from the final weight and dividing the difference by the total number of feeding days. Feed conversion efficiency (FCE) was determined as the ratio of ADG to average daily feed intake (ADFI), following the method described by [15].

Carcass characteristics

At the end of the feeding trial, all lambs were fasted overnight, and their slaughter body weight was recorded. Three lambs from each treatment group were then randomly selected for detailed carcass assessment. Slaughtering was carried out by severing the jugular vein and carotid artery, and the blood was collected and weighed immediately after exsanguination. Carcass dressing and systematic dissection followed. The skin was carefully removed to avoid tissue loss, and all major non-carcass components were separated and weighed individually.

These included blood, skin, head, feet, kidneys (with fat), lungs, trachea, esophagus, heart, liver (with gall bladder), spleen, testes, penis, the entire gastrointestinal tract, tail, and tongue.
Empty body weight (EBW) was calculated as slaughter weight minus gut fill. Hot carcass weight (HCW) was recorded after removing the blood, skin, head, feet, gastrointestinal tract, and internal organs, following the procedures outlined by [16].

Dressing percentage was calculated on two bases:

- (HCW) slaughter body weight x100
- (HCW/EBW) x100

The rib-eye muscle area was measured by tracing the muscle surface between the 11th and 12th ribs onto plastic paper. The following composite components were calculated:
Edible offal (EO): sum of blood, kidneys, liver, omasum, abomasum, intestines, reticulo-rumen, kidney fat, tongue, heart, spleen, pancreas, and tail.
Not- eaten offal (NEO): sum of head (without tongue), feet, skin, esophagus, lungs, testis, penis, trachea, and gut content.
Usable products (UP): sum of hot carcass weight, edible offal, and skin.

Partial Budget Analysis

A partial budget analysis was conducted to evaluate the economic feasibility of the different treatments, following the procedure of [17]. This analysis accounted for all variable costs, (e.g. feed , vaccinations) and the returns from the sale of lambs in each treatment.
Net return (NR) was calculated as:
NR=Total Returns (TR) –Total Variable Costs (TVC)
The marginal rate of return (MRR), which indicates the return per additional unit of expenditure, was calculated as:
MRR% = (ΔNR /ΔTVC) x100
Where ΔNR is the change in net return and ΔTVC is the change in total variable cost between treatments.

Chemical Analysis

The chemical composition of the experimental feeds, refusals, and fecal samples was analyzed at the College of Agriculture, Arba Minch University (AMU). Representative samples of korch leaf meal, noug seed cake, and refused desho grass hay were ground to pass through a 1-mm sieve prior to analysis. Dry matter (DM), organic matter (OM), crude protein (CP), ash, crude fiber (CF), and ether extract (EE) were determined following the procedures outlined by [18], with crude protein quantified using the Kjeldahl method. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were analyzed according to the methods of [19]. For apparent digestibility determination, 20% subsamples of feces collected from each lamb were composited and analyzed for DM, OM, CP, ash, NDF, and ADF. The metabolizable energy (ME) content of the feeds was estimated from digestible organic matter (DOM) using the equation described by [15].

ME (MJ/kg DM) = 0.016 * DOM
Where DOM = g digestible OM/ kg DM .

Data analysis

Data on feed intake, nutrient digestibility, body weight change, and carcass characteristics were analyzed using analysis of variance (ANOVA) under the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS, Version 9.3). Correlations among feed intake, digestibility, and body weight gain were also computed. When significant differences were detected, treatment means were separated using the Least Significant Difference (LSD) test at the 5% significance level.
The model used for analyzing the experimental data was:
$\mathbf{Y_{ij} = \mu + t_i + b_j + e_{ij}}$
Where:

- $\mathbf{Y_{ij}}$ = response variable,
- $\boldsymbol{\mu}$ = overall mean,
- $\mathbf{t_i}$ = effect of the i^{th} treatment,
- $\mathbf{b_j}$ = effect of the j^{th} block,
- $\mathbf{e_{ij}}$ = random error associated with the i^{th} treatment in the j^{th} block.

Result

Chemical composition of Experimental feeds

The chemical composition of the feeds used in the experiment is presented in Table 2. All feed samples were analyzed for dry matter (DM), organic matter (OM), ash, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL).

Table 2. Chemical composition of the experimental feeds (% of Dry Matter)

Feed types		Chemical composition of the feeds					
	DM%	OM	ASH	CP	ADF	NDF	ADL
Korch *(Erytrinia Brucie)* leaf	99.43	77.46	12.68	24.21	40.91	43.26	21.28
Noug seed cake *(Guzia Abisinica)*	97.25	86.84	9.78	27.14	15.31	21.44	10.33
Wheat bran	96.15	63.22	4.45	19.76	12.7	24.24	7.56
Desho grass	99.64	70.27	12.66	7.27	27.33	63.32	11.66

Feed Intake, Growth Performance, and Feed Efficiency

Feed intake, average daily gain (ADG), and feed conversion efficiency of the experimental sheep are summarized in Table 3. Lambs receiving the T1 diet showed significantly higher ($p < 0.05$) total weight gain and ADG compared to those fed the T4 diet. Daily dry matter intake was also greater in the T1 group. Over the 90-day feeding period, the overall mean ADG for all lambs was 53.2 g/head/day. However, except for the difference observed between T1 and T4, ADG did not vary significantly among the remaining treatments. Likewise, initial body weight, final body weight, total dry matter intake, and feed efficiency (gain/feed) showed no significant differences among treatment groups.

Table 3. Feed intake, body weight gain and feed conversion efficiency of Doyogena lambs fed different experimental diets

Parameters	Treatments				Mean	SEM	SL
	T1	T2	T3	T4			
Initial weight (kg/head)	22	21.4	21.6	22.2	21.8	1.07	NS
Final weight (kg/head)	28.3	25.95	26	26.55	26.4	0.56	NS
Total body weight gain	6.3	4.55	4.4	4.35	5.9	2.28	NS
DM Daily feed intake (kg/head/day)	1.55	1.51	1.54	1.46	1.52	1.55	NS
Total DM feed intake (kg/head/90 days)	139.5	135.9	138.6	131.4	136.35	7.11	NS
Average daily gain (g/head/day)	70	50.56	48.89	43.35	53.2	7.6	*
Feed efficiency (Gain/ feed)	20	13.85	13.04	11.2	14.52	2.07	NS

SEM= Standard error mean; SL=significance level

Weight change trends

The body weight of the sheep increased over 90-day experimental period. While lambs fed higher level of *Erythrina brucei* leaf showed a decreasing trend in weight gain compared to those on lower levels, the overall differences in body weight across the weeks were not statistically significant (p>0.05). The trends of weight gain is illustrated in Figure 1.

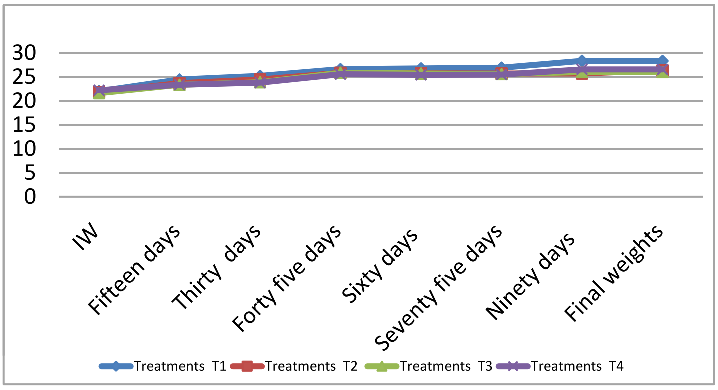

Figure 1: Weight gain trends of Doyogena growing lambs fed a basal diet of desho grass and supplemented with varying levels of Erthrnia brucei leaf
IW=initial weight

Carcass characteristics

The carcass characteristics of sheep fed the experimental diets are presented in Table 4. Substituting noug seed cake with *Erythrina brucei* leaf did not produce any statistically significant differences in slaughter weight, empty body weight, hot carcass weight, or dressing percentage. Lambs in the T2 group showed a numerically higher empty body weight, although the difference was not significant. The overall mean dressing percentage based on slaughter weight was 37.54%. Similarly, hind and forequarter weights, lumbar vertebrae measurements, rib and rib-eye muscle areas showed no significant variation among treatments.

Table 4. Carcass characteristics of Doyogena sheep as influenced by replacement of noug seed cake with Erythrnia brucei leaf

Parameters	Treatments				Mean	SEM	Sign. Level
	T1	T2	T3	T4			
SW(kg)	26.4	28	26.67	23.67	26.19	2.19	0.56
EBW(kg)	20.67	22	20	18	20.17	2.08	0.67
HCW(kg)	10.5	10.33	11	9.83	10.42	0.51	0.49
Dressing % based on SW	35.80	39.52	37.5	37.33	37.54	3.45	0.79
Dressing % based on EBW	50.8	47	55	54.6	51.12	5.22	0.8
Hind quarter weight (kg)	4.16	4.33	4.16	4	4.16	0.41	0.95
For quarter weight (kg)	5.9	4.17	4.33	4.17	4	0.37	0.95
Lumber vert.(gm)	510.33	700.33	685	661.33	639.25	50.46	0.10
Ribs(gm)	183.33	193.33	193.33	130	175	25.98	0.32
REMA (cm)*	1.5	1.7	1.47	2.00	1.67	0.29	0.41

SEM = Standard error of the mean; SW = Slaughter weight; EBW = Empty body weight; HCW = Hot carcass weight; REMA = Rib-eye muscle area; cm^2 = Square centimeter

Edible offal components

The weight of edible and non-edible offal components are presented in Table 5and 6 respectively. None of the offal components-including heart, liver, fat, head, skin, and lungs-were significantly affected by the dietary treatments. While there were numerical variations (e.g. total fat was lowest in T4), these differences were not statistically significant (p>0.05).

Table 5. Edible offal components (g) of Doyogena sheep

Edible offal	Treatments				Mean	SEM	Sign. Level
	T1	T2	T3	T4			
Heart (g)	147	138.21	155	120.33	140.17	10.27	0.18
Kidney (g)	77.33	74.22	67	65	70.92	5.10	0.33
Liver and bile (g)	328.67	320.33	347.33	315.33	327.93	17.29	0.60
Total fat (g)	129.67	54.67	50.33	37	70.17	21.65	0.07
Weight of empty gut (g)	836.67	904.67	1002.33	838.33	895.5	76.92	0.43
Intestinal weight (kg)	1.43	1.77	1.77	1.83	1.7	0.23	0.61
Tail weight (g)	518	386.33	513	393	452.58	112.25	0.74
Total edible offal(kg)	21.80	20.55	23.12	19.52	21. 25	0.37	0.11

SEM=Standard error means, sig=-significant, kg=kilogram, g-gram

Table 6. Non-edible components of Doyogena sheep

Non edible offal and non-carcass components	Treatments				Mean	SEM	SL
	T1	T2	T3	T4			
Head (gm)	147	138.33	155	120.33	140.17	10.74	0.18
Legs(gm)	250	313.33	370	303	309.08	28.96	0.10
Skin weight(kg)	2.20	1.93	2.23	1.9	2.07	0.10	0.09
Lunge and pancreas (gm)	374	327.67	311.67	267.33	320.17	25.62	0.10
Blood (g)	1011	1070	1016	1032.33	1032.33	57.85	0.89
Testicle weight (g)	393.67	354.67	347.33	358.67	363.58	16.30	0.27
Spleen (g)	54	53.67	51.33	37.67	49.17	6.63	0.32

SEM, Standard error means

Partial budget estimation

An economic analysis using partial budget estimation was conducted (Table 7). The net profit per head over the 90-day experimental period was higher for the T4 diet at 2059.82 ETB, followed T1 (1813.39 ETB), 1699.78 ETB for T2 and 1681.58 ETB for T3.

Table 7. Partial budget analysis (Ethiopian Birr, ETB) for feeding Doyogena lambs with Erythirnia brucei leaf as a substitute of noug seed cake

s/no.	Items	T1	T2	T3	T4
1	Total feed consumed(Kg/head/90 days) (Feed	1126	839.35	779.16	710
	cost ETB)				
2	purchase price of lambs	1435	1435	1435	1435
3	Medication cost	45.12	39.17	42.19	35.18
4	Total cost (feed price+ medicament price+ purchase price of sheep)	2606.12	2313.52	2256.35	2580.18
5	Sale price of sheep	4300	4220	4212	4240
6	Net return (sale price - total cost)	1813.39	1699.78	1681.58	2059.82

Discussion

Feed intake and feed conversion efficiency

Feed intake is influenced by multiple factors, including feed type, texture, physical form, environmental conditions such as temperature, and the presence of anti-nutritional factors [20]. The proportion of energy to protein in the diet is also a critical determinant. In this study, the inclusion of *Erythrina brucei* leaf resulted in a higher Feed Conversion Efficiency (FCE), a finding consistent which previous research on the value of korch leaf for growing lambs [21]. Such locally available, protein-rich feeds and fodders are both affordable and accessible for smallholder farmers. Several major local protein sources have already been identified for use in the crop-livestock systems of central Ethiopia [8], while other feed categories have been noted as inadequate for supporting growth [22]. The results indicate that dry matter (DM) intake was statistically similar ($P<0.05$) across all treatment groups of sheep (Table 3). Consequently, no significant differences in intake were observed among the supplemented animals. DM intake was observed for all treatment sheep receiving diets (Table 3). Therefore, no significant differences were observed among the supplemented animals.

Pattern of weight changes

In rural communities, it is common practices to sell lambs once they achieve optimal growth, as prolonged increases production costs [22], [10], [23], [21]. A key management strategy for improving productivity is therefore to maximize weight gain while minimizing labor and feed expenses. Weight gain is itself affected by feed preparation (physical or chemical treatment), feed quality (energy and protein content), environmental temperature, and the health of the animals. In the present study, no weight losses occurred during the experimental period. The use of an efficient grower ration could enable lambs to reach export market weight (25-30 kg), within a short period, such as three months. This is particularly advantageous given recurring feed cost inflation. To farther shorten the finishing period, supplement level could potentially be adjusted. For export market, over-fattening is unnecessary and cost-ineffective, as it primarily leads to fat deposition once animals have reached optimal growth.

While animal weight can fluctuate due to factors like feed texture of health, the sheep supplemented with increasing level of *Erythrina brucei* leaf exhibited a consistent weight increase throughout the study. This aligns finding from [23], who reported a similar study weight gain in oxen fed local energy-rich feeds, this trend is not always linear and can be influenced by animal health, feed forms, and environmental temperature [22]. The weight gain observed in this research was higher than that of reported for goat fed *Erythrnia brucei* leaf [24] and for sheep fed sensel *(Justicia Schemperiana)* leaf meal [21].

Carcass characteristics

Carcass yield and composition are direct functions of an animal's diet. The higher slaughter weight (SW) and empty body weight (EBW) in sheep the T1 supplemented could be attributed to the high protein level released from Erythrina brucei; this effect declined at higher inclusion levels. This suggests that the higher level of noug cake supplementation may have limited DM intake, metabolizable energy (ME) intake, nutrient digestibility, and dressing percentage. This is supported by [25], who found that dressing percentage increases with higher total DM and nutrient intake. The lack of significant differences in dressing percentage (DP) and hot carcass weight (HCW) among sheep supplemented with various level of *Erythrina brucei* leaf may be due to the partitioning of weight gain between carcass and non carcass components, which minimized differences between groups. This finding is consistence with [27], who observed similar DP in Gaddi sheep across nutritional planes, indicating that nutrition did not significantly affect this trait, the DP values on EBW from this study are higher than the values of 41.34 % and 41.79%, and 39.9% reported by [28], [21] for Somali and Mid-Rift Valley sheep raised on concentrate-based diets.

Partial Budget Estimation

Profitability is essential for both private enterprises and smallholder farmers to sustain sheep fattening operations. In the mixed farming systems of the central-south region, the benefits of growing and fattening enterprises have been well documented [22, 23]. Energy-dense feeds are particularly important for accelerated fattening during festive seasons, as they enable faster weight gain, reduce labor and feed costs, and improve overall profitability [23]. Farmers in these areas have also developed informal insurance schemes to increase the number of fattening animals while minimizing risks such as mortality, theft, or loss [22]. Access to credit can further enhance these practices by providing the resources needed for strategic, holiday-targeted fattening. In the partial analysis shown in Table 7, treatment T4 recorded the lowest performance compared to all other treatments.

Conclusion

The study demonstrated that feeding korch (*Erythrina brucei*) leaf to growing lambs resulted in a satisfactory mean daily gain of 53.2 g/day over three months, indicating its potential as a viable feed resource for both smallholder farmers and private enterprises. Partial budget analysis further confirmed the economic feasibility of strategic supplementation. The lack of significant differences among treatments suggests that korch leaf could effectively replace noug cake meal or commercial concentrates with locally available protein-rich sources for Doyogena sheep. Further research is recommended to evaluate potential antinutritional effects and to determine the optimal and higher inclusion levels for improved growth performance.

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